

What Is Claimed:

Sub A23
1) An electrophysiology/ablation catheter comprising:

- a) an elongated flexible hollow tubular casing having a proximal end and distal end and a plurality of spaced electrodes disposed at the distal end thereof;
- b) a pair of flexible tension/compression members disposed in side by side relationship and extending in the hollow of said casing from a point of attachment adjacent said distal end to said proximal end of said tubular casing;
- c) an electrical lead connected to each of said electrodes and extending through the hollow of said tubular casing to the proximal end thereof, said lead adapted for external connections thereto;
- d) spacer means disposed between said pair of flexible tension/compression members at said distal end for maintaining lateral spacing between said members, said spacer means being flexible; and,
- e) wherein longitudinal tensioning of a first of said tension/compression members and simultaneously longitudinal compressing of the second of said tension/compression members with respect to said casing effects lateral displacement of said distal end of said casing in one direction and longitudinal tensioning of the said second of tension/compression members and simultaneously longitudinal compressing of the said first of said tension/compression members with respect to said casing effects lateral displacement of said distal end of said casing in a direction opposite said one direction.

2) The catheter defined in Claim 1, wherein said pair of tension/compression members each have a portion thereof adjacent said distal end formed to have a flattened transverse section.

3) The catheter defined in Claim 1, wherein said spacer means comprises a blade spring member.

4) The catheter defined in Claim 1, wherein said spacer means comprises a wave shaped spring member.

Sub A24
5) The catheter defined in Claim 1, wherein each of said tension/compression members has substantially rectangular transverse section in the region adjacent said distal portion with

the balance thereof having a generally circular cross-section.

8. 6) The catheter defined in Claim 1, further comprising an elongated flexible tubular guide member disposed in said casing, said guide member having a pair of spaced parallel lumens formed therein with one of said pair of tension/compression members disposed in each lumen.

Sub A25 7) The catheter defined in Claim 1, further comprising a sleeve received over said flattened portion of said tension/compression members and spaced a preselected distance from said distal end, said tension/compression members secured therein and forming a kinematic junction at said sleeve, wherein the portion of said tubular casing distal said sleeve remains substantially un-deformed upon simultaneous tensioning and compressing of said tension/compression members.

4. 8) The catheter defined in Claim 7, wherein said spacer means has an end thereof secured in said sleeve with the other end of said spacer floating in the space between said tension/compression members.

9) The catheter defined in Claim 1, further comprising an elongated flexible tubular guide member disposed in said casing with said tension/compression members received therethrough; and, a rigid collar attached to the distal end of said guide member and extending over a portion of said tension/compression members having said spacer means therebetween.

10) The catheter defined in Claim 9, wherein said rigid collar has a flattened cross-section on one end and a generally circular cross-section on an end opposite said one end.

11) The catheter defined in Claim 1, further comprising an annular reference electrode disposed on said tubular casing at a station therealong remote from said plurality of spaced electrodes, wherein said reference electrode is located such that it remains exterior to the heart cavity upon insertion of the said plurality of spaced electrodes into a heart cavity.

12) A method of making an electrophysiology/ablation catheter comprising:

a) disposing at least one electrode on a distal portion of an elongated flexible tubular member and connecting an electrode lead to said electrode and extending said electrode lead to a proximal end of said tubular member;

b) disposing a pair of elongated tension/compression members in said tubular member and fixing an end of each of said pair in the distal portion of said tubular member and extending said pair to the proximal end of said tubular member;

- c) disposing a flexible spacer intermediate said tension/compression members in the region of the distal portion thereof and spacing said tension/compression members laterally;
 - d) disposing an actuator movably on a handle and connecting said handle to the proximal end of said tubular member; and,
 - e) connecting said actuator to the proximal ends of said tension/compression members.
- 13) The method defined in Claim 12, wherein said of fixing includes securing by weldment.
- 14) The method defined in Claim 12, wherein said step of disposing a flexible spacer includes securing an end of said spacer to said tension/compression members by weldment.
- 15) The method defined in Claim 12, wherein said step of disposing a flexible spacer includes flattening a portion of the distal end of said tension/compression members and securing an end of said spacer thereto by weldment.
- 16) The method defined in Claim 12, further comprising disposing a sleeve over said tension/compression members and positioning said sleeve a preselected distance from said distal end and securing said sleeve to said tension/compression members and forming a kinematic junction thereof at said sleeve
- 17) The method defined in Claim 12, wherein said fixing includes disposing an additional flexible tube within said casing a certain distance from said distal end and partially stiffening a portion of said tubular member.
- 18) A method of installing a distal electrode to an electrophysiology/ablation catheter comprising:
- a) providing a generally cup-shaped member of electrically conductive material and forming a plurality of spaced fingers extending axially from the rim of said cup-shaped member;
 - b) disposing the open end of said cup-shaped member over an end of a tubular catheter casing member and deforming said fingers radially inwardly and passing at least one said fingers through the wall of said tubular member and securing said cup-shaped member to said tubular member with said finger; and,

- c) attaching an electrical lead to said at least one finger and extending said lead through said tubular member.
- 19) The method defined in Claim 18, wherein said step of securing includes further deforming said fingers and extending said at least one finger along the inner surface of said tubular member.
- 20) The method defined in Claim 18, wherein each step of securing includes further deforming said at least one finger to fold back on itself along the inner surface of the said tubular member.
- 21) The method defined in Claim 18, wherein said step of passing said at least one finger through said tubular member includes piercing said wall with said at least one finger.
- 22) A motorized electrophysiology/ablation catheter actuating assembly comprising:
- a) an elongated flexible tubular member having a distal end and a proximal end and having a pair of tension/compression members disposed therein and kinematically joined in said distal end, said tension/compression members extending through the proximal end of said tubular member;
 - b) hollow handle structure attached to the proximal end of said tubular member, said handle structure having therein a motor drive including means for converting motor rotation to linear movement with the proximal ends of said tension/compression members connected to said means for converting,
 - c) a source of electrical power disposed in said handle structure and user operated switch means disposed on said handle structure for energizing said motor drive, wherein said motor drive is operative, upon being energized for rotation in one direction, to cause said means for converting rotation to simultaneously pull and push said first and second tension/compression members respectively and effect curvature of said tubular member in one direction; and said motor drive is operative, upon being energized for rotation in a direction opposite said one direction to cause said means for converting rotation to simultaneously pull and push said second and first tension/compression members respectively and effect curvature of said tubular member in the opposite direction.
- 23) The assembly defined in Claim 22, wherein said handle structure includes a position sensor for sensing the position of a member of said means for converting motor rotation to linear motion as an indication of the radius of curvature of the distal portion of said tubular member.

- 24) The assembly defined in Claim 22, wherein said handle structure includes connector means adapted for external electrical connection; and, said tubular member includes lead means connected to at least one distal electrode, said lead means having the proximal end thereof connected to said connector means.
- 25) The assembly defined in Claim 22, wherein said connector means includes connections for remote control of said motor drive.
- 26) The catheter defined in Claim 1 further comprising a solid state temperature sensor disposed in said distal electrode and sensing lead means connected to said sensor, said sensing leads means extending through said casing to the proximal end thereof for connection to a sensing circuit.
- 27) The catheter defined in Claim 1 further comprising a fiber optic temperature sensor received through said casing, having an end thereof connected to said distal electrode for conducting a temperature sensing signals to the proximal end thereof.
- 28) The catheter defined in Claim 1 further comprising:
- a) heating element disposed in said distal electrode;
 - b) electrical supply lead means connected to said distal electrode, said supply lead means extending through said casing to the proximal end thereof wherein upon powering said lead means, said distal electrode is heated.
 - c) electric power supply and temperature control module disposed in said handle to control the temperature of said distal electrode for ablation procedures.
- 29) The catheter defined in Claim 28 further comprising a solid state temperature sensor disposed in said distal electrode and sensing lead means connected to said sensor, said sensing leads means extending through said casing to the proximal end thereof for connection to a sensing circuit disposed in said handle.
- 30) The catheter defined in Claim 1, wherein said distal portion of said tension/compression members are received in a flexible guide tube disposed within said casing, said guide tube having an end engaging said distal electrode.
- 31) The catheter defined in Claim 28, wherein said flexible guide tube has a pair of internal septum formed therein extending the length thereof for separating said tension/compression members and said spacer means

- 32) The catheter defined in Claim 1, wherein the proximal end of each of said tension/compression members is received in a closely fitting metal tube; and, said metal tube is deformed by clamping and said tube and tension/compression member are secured to a reciprocating member operationally connected to said actuator member.
- 33) The catheter defined in Claim 1, wherein said handle includes a pair of reciprocating members operationally connected to said actuator member, with each reciprocating member connected to one of said tension/compression members; and, said handle includes a displacement sensor operative to sense the motion of at least one of said reciprocating members.
- 34) The catheter defined in Claim 1, wherein said handle includes means operable for frictionally securing said actuator in a user selected position.
- 35) The catheter of Claim 34, wherein said means for frictionally securing includes an elastic rubber.
- 36) The catheter defined in Claim 32, wherein said means for frictionally securing includes a spring loaded plunger.
- 37) The catheter defined in Claim 1 further comprising an elastic collar received over the proximal end of said casing, said collar operable to grip said casing upon user grasping thereof for enabling the user to readily apply torque to said casing.
- 38) The catheter defined in Claim 37, wherein said collar is axially moveable along said casing for permitting user selection of the region of torque application therealong.
- 39) A method of installing an annular electrode on a flexible catheter casing comprising:
- a) attaching an end of an electrical lead to said electrode;
 - b) forming an aperture in said casing and passing the remote end of said lead through said aperture;
 - c) securing the proximal end of the casing over a rigid tube;
 - d) stretching said casing axially, necking said casing and sliding said electrode over said casing and positioning said electrode over said aperture with said lead therethrough;
 - e) releasing said stretching to expand said necking and securing said electrode on said casing; and,
 - f) removing excess casing material.
- 40) The catheter defined in Claim 1, wherein said distal electrode and said plurality of spaced annular electrodes are made from electrically conductive rubber-like material.

Add new